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Annual and semi-annual cycle of equatorial Atlantic circulation associated with basin mode resonance

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Seasonal variability of the tropical Atlantic circulation is dominated by the annual cycle, but semi-annual variability is also pronounced, despite weak forcing at that period. Here we use multi-year, full depth velocity measurements from the central equatorial Atlantic to analyze the vertical structure of annual and semi-annual variations of zonal velocity. A baroclinic modal decomposition finds that the annual cycle is dominated by the 4th mode and the semi-annual cycle by the 2nd mode. Similar local behavior is found in a high-resolution general circulation model. This simulation reveals that the annual and semi-annual cycles of the respective dominant baroclinic modes are associated with characteristic basin-wide structures. Using an idealized linear reduced-gravity model to simulate the dynamics of individual baroclinic modes, it is shown that the observed circulation variability can be best explained by resonant equatorial basin modes. Companion simulations using the reduced-gravity model varying the basin geometry, i.e. square basin versus realistic coastlines, and forcing, i.e. spatially uniform versus spatially varying wind forcing, show a structural robustness of the simulated basin modes. A main focus of this study is the seasonal variability of the Equatorial Undercurrent (EUC) as identified in recent observational studies. Main characteristics of the observed EUC including seasonal variability of transport, core depth, and maximum core velocity can be explained by the linear superposition of the dominant equatorial basin modes as obtained from the reduced-gravity model.